Oxygen and nitrous oxide fluxes
in the oxygen minimum zone off West Africa

SOPRAN SFB 754

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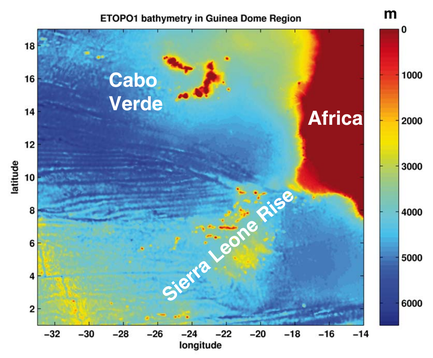
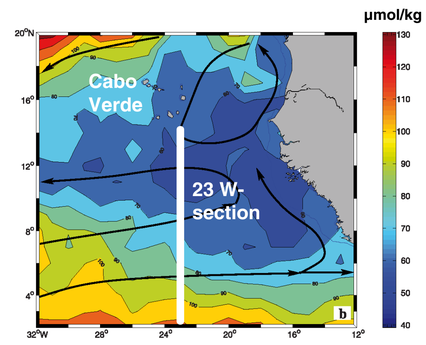
Oxygen minimum zone (OMZ) off West Africa

Bottom topography



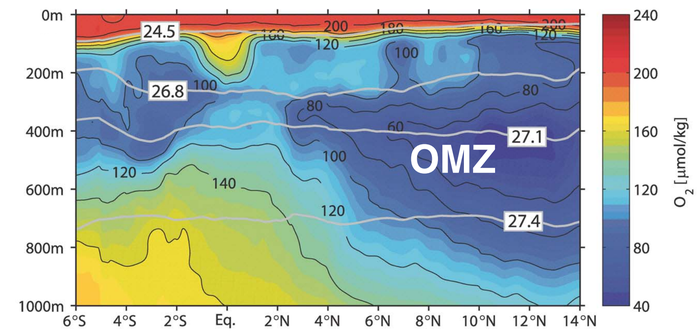
Oxygen distribution at 400 m level



[Stramma et al. 2008], modified.

black arrows: surface currents

Oxygen along 23 W meridional section



[Brandt et al. 2010], modified.

black lines: oxygen concentration isolines
white lines: density isolines

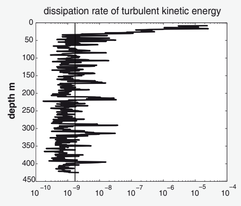
$\Phi = K \cdot \nabla c$

Diapycnal fluxes by direct diffusive method during 3 cruises in 2008-2010.
K : diapycnal diffusivity
∇c : vertical concentration gradient

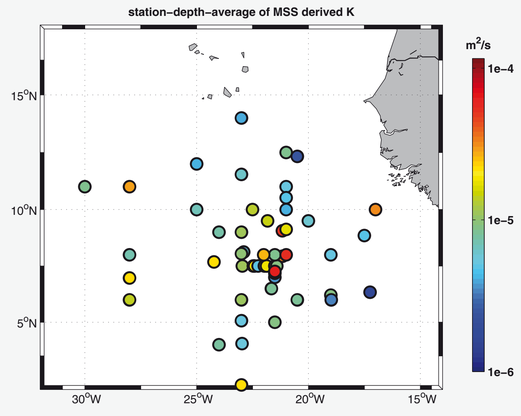
K from microscale velocity fluctuations

MSS Profiler with airfoil shear sensors

dissipation rate of turbulent kinetic energy



station–depth–average of MSS derived K

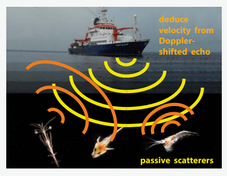


MSS: $\bar{K} = 1.1 \cdot 10^{-5} \pm 0.4 \cdot 10^{-5}$ m²/s

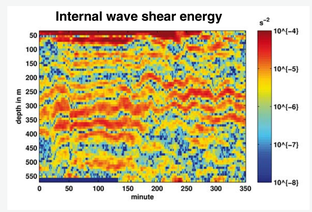
A large-scale Tracer Release Experiment (TRE) in 2008 to 2010 yielded $K = 1.2 \cdot 10^{-5} \pm 0.1 \cdot 10^{-5}$ m²/s [Banyte et al. 2011]

K from ADCP acoustic survey of internal wave field, a proxy for mixing intensity

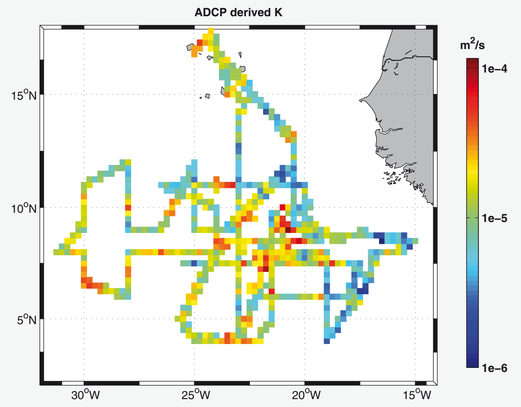
Acoustic Doppler Current Profiler



Internal wave shear energy



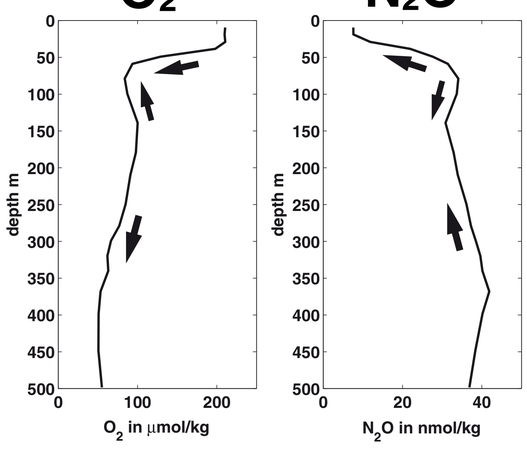
ADCP derived K



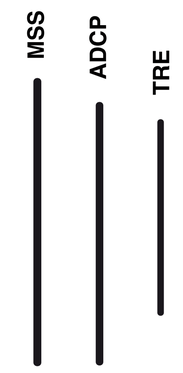
ADCP: $\bar{K} = 1.2 \cdot 10^{-5} \pm 0.2 \cdot 10^{-5}$ m²/s

∇c from CTD and/or water samples

Typical concentration profiles



Depth ranges of K estimates by method



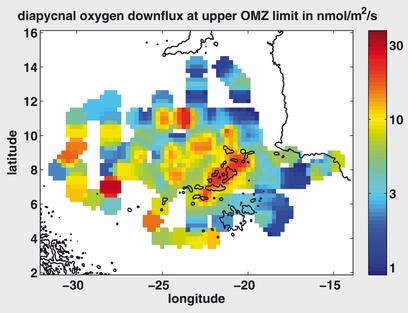
Direction of diapycnal flux as caused by concentration gradient

Constraints in depth range (method dependent) confine estimates of diapycnal fluxes to the upper half of the OMZ. The existence of a shallow oxygen minimum / N_2O maximum in large parts of the OMZ decouples diapycnal fluxes at the OMZ upper border from the local mixed layer and atmosphere.

Diapycnal fluxes and flux divergences of oxygen and nitrous oxide as part of the OMZ budget

O_2 downward flux into upper OMZ

diapycnal oxygen downflux at upper OMZ limit in nmol/m²/s



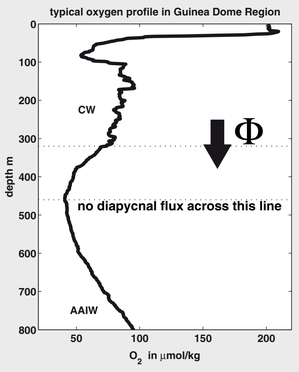
Enhanced flux at and west of Sierra Leone Rise

$\Phi = 6.2 \pm 0.7$ nmol/m²/s

$\nabla\Phi = 1.7 \pm 0.2$ µmol/kg/a

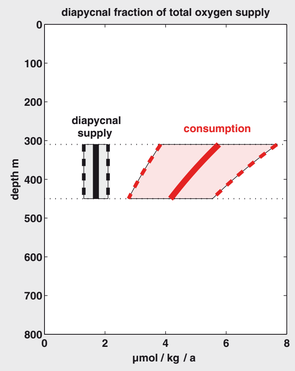
Inferences on oxygen budget of OMZ's upper part

typical oxygen profile in Guinea Dome Region



CW: Central Water
AAIW: Antarctic Intermediate Water

diapycnal fraction of total oxygen supply

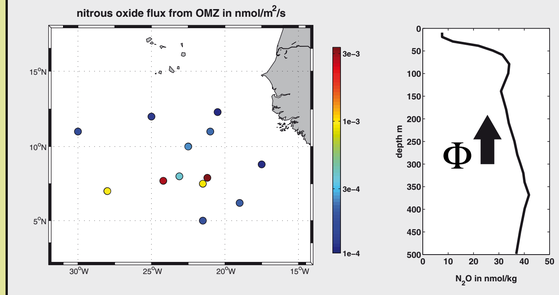


Consumption estimated for Atlantic and Pacific OMZs by Karstensen et al. 2008

Our estimated diapycnal supply is 20-50% of estimated consumption. Brandt et al. (2010) estimate 15-40% from a conceptual model.

N_2O upward flux from upper OMZ

nitrous oxide flux from OMZ in nmol/m²/s



$\Phi = 1.0 \cdot 10^{-3} \pm 0.4 \cdot 10^{-3}$ nmol/m²/s

$\nabla\Phi = 250 \pm 100$ pmol/kg/a

References

Banyte, Tanhua, Visbeck, Wallace, Karstensen, Krahmann, Schneider, Stramma 2011: *Vertical diffusivity at the upper boundary of the North Tropical Atlantic oxygen minimum zone* [in prep.]
Brandt, Hormann, Körtzinger, Visbeck, Krahmann, Stramma, Lumpkin, Schmid 2010: *Changes in the ventilation of the oxygen minimum zone of the Tropical North Atlantic* J. Phys. Oceanogr. 40, 1784-1801
Karstensen, Stramma, Visbeck 2008: *Oxygen minimum zones in the eastern tropical Atlantic and Pacific oceans* Prog. Oceanogr. 77, 331-350
Stramma, Brandt, Schafstall, Schott, Fischer, Körtzinger 2008: *Oxygen minimum zone in the North Atlantic south and east of the Cape Verde Islands* J. Geophys. Res. 113, C04014